IX. *An Account of the* Ganges *and* Burrampooter *Rivers. By* James Rennell, *Esq. F. R. S.; communicated by* Joseph Banks, *Esq. P. R. S.*

Read January 25, 1781.

THE * Ganges and † Burrampooter Rivers, together with their numerous branches and adjuncts, interſect the country of Bengal in ſuch a variety of directions, as to form the moſt compleat and eaſy inland navigation that can be conceived. So equally and admirably diffuſed are thoſe natural canals, over a country that approaches nearly to a perfect plane, that, after excepting the lands contiguous to Burdwan, Birboom, &c. (which altogether do not conſtitute a ſixth part of Bengal) we may fairly pronounce, that every other part of the country has, even in the dry ſeaſon, ſome navigable ſtream within 25 miles at fartheſt, and more commonly within a third part of that diſtance.

It is ſuppoſed, that this inland navigation gives conſtant employment to 30,000 boatmen. Nor will it be wondered at, when it is known, that all the ſalt, and a large proportion of the

* The proper name of this river in the language of Hindooſtan (or Indoſtan) is Pudda or Padda. It is alſo named Burra-Gonga, or the Great River; and Gonga, the River, by way of eminence; and from this, doubtleſs, the European names of the river are derived.

† The orthography of this word, as given here, is according to the common pronunciation in Bengal; but it is ſaid to be written in the Sanſcrit language, Brahma-pootar, which ſignifies the Son f Brahma.

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food conſumed by ten millions of people are conveyed by water within the kingdom of Bengal and its dependencies. To theſe muſt be added, the tranſport of the commercial exports and imports, probably to the amount of two millions ſterling *per annum*; the interchange of manufactures and products throughout the whole country; the fiſheries; and the article of travelling *.

Theſe rivers, which a late ingenious gentleman aptly termed ſiſters and rivals (he might have ſaid *twin* ſiſters, from the contiguity of their ſprings), exactly reſemble each other in length of courſe; in bulk, until they approach the ſea; in the ſmoothneſs and colour of their waters; in the appearance of their borders and iſlands; and, finally, in the height to which their floods riſe with the periodical rains. Of the two, the Burrampooter is the largeſt; but the difference is not obvious to the eye. They are now well known to derive their ſources from the vaſt mountains of Thibet †; from whence they proceed in oppoſite directions; the Ganges ſeeking the plains of Hindooſtan (or Indoſtan) by the weſt; and the Burrampooter by the eaſt; both purſuing the early part of their courſe through rugged vallies and defiles, and ſeldom viſiting the habitations of men. The Ganges, after wandering about 750 miles through theſe mountainous regions, iſſues forth a deity to the ſuperſti-

* The embarkations made uſe of vary in bulk from 180 tons down to the ſize of a wherry. Thoſe from 30 to 50 tons are reckoned the moſt eligible for tranſporting merchandize.

† Theſe are amongſt the higheſt of the mountains of the old hemiſphere. I was not able to determine their height; but it may in ſome meaſure be gueſſed, by the circumſtance of their riſing conſiderably above the horizon, when viewed from the plains of Bengal, at the diſtance of 150 miles.

tious, yet gladdened, inhabitant of Hindooſtan *. From Hurdwar (or Hurdoar) in latitude 30°, where it guſhes through an opening in the mountains, it flows with a ſmooth navigable ſtream through delightful plains during the remainder of its courſe to the ſea (which is about 1350 miles) diffuſing plenty immediately by means of its living productions; and ſecondarily by enriching the adjacent lands, and affording an eaſy means of tranſport for the productions of its borders. In a military view, it opens a communication between the different poſts, and ſerves in the capacity of a *military way* through the country; renders unneceſſary the forming of magazines; and infinitely ſurpaſſes the celebrated inland navigation of North America, where the *carrying places* not only obſtruct the progreſs of an army, but enable the adverſary to determine his place and mode of attack with certainty.

In its courſe through the plains, it receives eleven rivers, ſome of which are equal to the Rhine, and none ſmaller than the

* The fabulous account of the origin of the Ganges (as communicated by my learned and ingenious friend C. W. BOUGHTON ROUSE, Eſq.) is, that it flows out of the foot of Beſchan * (from whence, ſay the Bramins, it has its name Padda; that word ſignifying foot in the Sanſcrit language); and that in its courſe to the plains of Hindooſtan it paſſes through an immenſe rock ſhaped like a Cow's-head.

The allegory is highly expreſſive of the veneration which the Hindoos have for this famous ſtream; and no leſs ſo of their gratitude to the Author of Nature for beſtowing it: for it deſcribes the bleſſing as flowing purely from his bounty and goodneſs.

The rock before mentioned has, I believe, never been viſited by any European; and is even allowed by moſt of the natives to bear no reſemblance to the object from whence it is denominated. However, as the effects of ſuperſtition do often long ſurvive the illuſions that gave it birth, the rock or cavern ſtill preſerves the name of *Gowmooky*, or Cow's-head.

* Beſchan is the ſame with Viſtnou, the PRESERVING DEITY.

Thames, beſides as many others of leſſer note. It is owing to this vaſt influx of ſtreams, that the Ganges exceeds the Nile ſo greatly in point of magnitude, whilſt the latter exceeds it in length of courſe by one-third. Indeed, the Ganges is inferior in this laſt reſpect, to many of the northern rivers of Aſia; though I am inclined to think that it diſcharges as much or more water than any of them, becauſe thoſe rivers do not lie within the limits of the periodical rains *.

The bed of the Ganges is, as may be ſuppoſed, very unequal in point of width. From its firſt arrival in the plains at Hurd-

* The proportional lengths of courſe of ſome of the moſt noted rivers in the world are ſhewn nearly by the following numbers:

European Rivers.	
Thames,	1
Rhine,	$5\frac{1}{4}$
Danube,	7
Wolga,	$9\frac{1}{2}$
Aſiatic rivers.	
Indus,	$5\frac{1}{2}$
Euphrates,	$8\frac{1}{2}$
Ganges,	$9\frac{1}{2}$
Burrampooter,	$9\frac{1}{2}$
Nou Kian, or Ava River,	$9\frac{1}{2}$
Jenniſea,	10
Oby,	$10\frac{1}{2}$
Amoor,	11
Lena,	$11\frac{1}{2}$
Hoanho (of China),	$13\frac{1}{2}$
Kian Keu (of ditto),	$15\frac{1}{2}$
African river.	
Nile,	$12\frac{1}{2}$
American rivers.	
Miſſiſipi,	8
Amazons,	$15\frac{3}{4}$

war,

war, to the conflux of the Jumnah (the firſt river of note that joins it) its bed is generally from a mile to a mile and a quarter wide; and, compared with the latter part of its courſe, tolerably ſtraight. From hence, downward, its courſe becomes more winding, and its bed conſequently wider *, till, having alternately received the waters of the Gogra, Soane, and Gunduck, beſides many ſmaller ſtreams, its bed has attained its full width; although, during the remaining 600 miles of its courſe it receives many other principal ſtreams. Within this ſpace it is, in the narroweſt parts of its bed, half a mile wide, and in the wideſt, three miles; and that, in places where no iſlands intervene. The ſtream within this bed is always either increaſing or decreaſing, according to the ſeaſon. When at its loweſt (which happens in April) the principal channel varies from 400 yards to a mile and a quarter; but is commonly about three quarters of a mile.

The Ganges is fordable in ſome places above the conflux of the Jumnah, but the navigation is never interrupted. Below that, the channel is of conſiderable depth, for the additional ſtreams bring a greater acceſſion of depth than width. At 500 miles from the ſea, the channel is thirty feet deep when the river is at its loweſt; and it continues at leaſt this depth to the ſea, where the ſudden expanſion of the ſtream deprives it of the force neceſſary to ſweep away the bars of ſand and mud thrown acroſs it by the ſtrong ſoutherly winds; ſo that the principal branch of the Ganges cannot be entered by large veſſels.

About 220 miles from the ſea (but 300 reckoning the windings of the river) commences the head of the Delta of the Ganges, which is conſiderably more than twice the area of that of the Nile. The two weſternmoſt branches, named the

* This will be explained when the windings of the river are treated of.

Coſſimbuzar and Jellinghy Rivers, unite and form what is afterwards named the Hoogly River, which is the port of Calcutta, and the only branch of the Ganges that is commonly navigated by ſhips *. The Coſſimbuzar River is almoſt dry from October to May; and the Jellinghy River (although a ſtream runs in it the whole year) is in ſome years unnavigable during two or three of the dryeſt months; ſo that the only ſubordinate branch of the Ganges, that is at all times navigable, is the Chundnah River, which ſeparates at Moddapour, and terminates in the Hooringotta.

That part of the Delta bordering on the ſea, is compoſed of a labyrinth of rivers and creeks, all of which are ſalt, except thoſe that immediately communicate with the principal arm of the Ganges. This tract, known by the name of the Woods, or Sunderbunds, is in extent equal to the principality of Wales; and is ſo completely enveloped in woods, and infeſted with Tygers, that if any attempts have ever been made to clear it (as is reported) they have hitherto miſcarried. Its numerous canals are ſo diſpoſed as to form a compleat inland navigation throughout and acroſs the lower part of the Delta, without either the delay of going round the head of it, or the hazard of putting to ſea. Here ſalt, in quantities equal to the whole conſumption of Bengal and its dependencies, is made

* The Hoogly River, or weſternmoſt branch of the Ganges, has a much deeper outlet to the ſea than the principal branch. Probably this may be owing to its precipitating a leſs quantity of mud than the other; the quantity of the Ganges water diſcharged here being leſs than in the other in the proportion of one to ſix. From the difficulties that occur in navigating the entrance of the Hoogly River, many are led to ſuppoſe, that the channels are ſhallow. The difficulties, however, ariſe from bringing the ſhips acroſs ſome of the ſand-banks, which project ſo far into the ſea, that the channels between them cannot eaſily be traced from without.

and tranſported with equal facility: and here alſo is found an inexhauſtible ſtore of timber for boat-building. The breadth of the lower part of this Delta is upwards of 180 miles; to which, if we add that of the two branches of the river that bound it, we ſhall have about 200 miles for the diſtance to which the Ganges expands its branches at its junction with the ſea.

It has been obſerved before, that the courſe of this river, from Hurdwar to the ſea, is through an uniform plain, or, at leaſt, what appears ſuch to the eye: for, the declivity is much too ſmall to be perceptible. A ſection of the ground, parallel to one of its branches, in length 60 miles, was taken by order of Mr. HASTINGS; and it was found to have about nine inches deſcent in each mile, reckoning in a ſtraight line, and allowance being made for the curvature of the earth. But the windings of the river were ſo great, as to reduce the declivity on which the water ran, to leſs than four inches *per* mile: and by a compariſon of the velocity of the ſtream at the place of experiment with that in other places, I have no reaſon to ſuppoſe, that its general deſcent exceeds it *.

The medium rate of motion of the Ganges is leſs than three miles an hour in the dry months. In the wet ſeaſon, and during the draining off of the waters from the inundated lands, the current runs from five to ſix miles an hour; but there are inſtances of its running ſeven, and even eight miles, in particular ſituations, and under certain circumſtances. I have an

* M. DE CONDAMINE found the deſcent of the river Amazons, in a ſtraight courſe of about 1860 miles, to be about 1020 Engliſh feet, or $6\frac{1}{3}$ inches in a mile. If we allow for the windings, it comes out nearly the ſame as the Ganges (which winds about $1\frac{1}{9}$ mile in three, taking its whole courſe through the plains), namely, about 4 inches in a mile.

experiment

experiment of my own on record, in which my boat was carried 56 miles in eight hours; and that againſt ſo ſtrong a wind, that the boat had evidently no progreſſive motion through the water.

When we conſider, that the velocity of the ſtream is three miles in one ſeaſon, and five or more in the other, on the ſame deſcent of four inches *per* mile; and, that the motion of the inundation is only half a mile *per* hour, on a much greater deſcent; no further proof is required how ſmall the proportion of velocity is, that the deſcent communicates. It is then, to the impetus originating at the ſpring head, or at the place where adventitious waters are poured in, and ſucceſſively communicated to every part of the ſtream, that we are principally to attribute the velocity, which is greater or leſſer, according to the quantity of water poured in.

In common, there is found on one ſide of the river an almoſt perpendicular bank, more or leſs elevated above the ſtream, according to the ſeaſon, and with deep water near it: and on the oppoſite ſide a bank, ſhelving away ſo gradually as to occaſion ſhallow water at ſome diſtance from the margin. This is more particularly the caſe in the moſt winding parts of the river, becauſe the very operation of winding produces the ſteep and ſhelving banks *: for the current is always ſtrongeſt on the external ſide of the curve formed by the ſerpentine courſe of the river; and its continual action on the banks

* Hence it is, that the ſection of a river, that winds through a looſe ſoil, approaches nearly to an obtuſe angled-triangle, one of whoſe ſides is exceedingly ſhort and diſproportioned to the other two . But when a river perſeveres in a ſtraight courſe, the ſection becomes nearly the half of an ellipſis divided longitudinally .

either

either undermines them *, or waſhes them down. In places where the current is remarkably rapid, or the ſoil uncommonly looſe, ſuch tracts of land are ſwept away in the courſe of one ſeaſon, as would aſtoniſh thoſe who have not been eye-witneſſes to the magnitude and force of the mighty ſtreams occaſioned by the periodical rains of the tropical regions. This neceſſarily produces a gradual change in the courſe of the river; what is loſt on one ſide being gained on the other, by the mere operation of the ſtream: for the fallen pieces of the bank diſſolve quickly into muddy ſand, which is hurried away by the current along the border of the channel to the point from whence the river turns off to form the next reach, where the ſtream growing weak, it finds a reſting place, and helps to form a ſhelving bank, which commences at the point, and extends downwards, along the ſide of the ſucceeding reach.

To account for the ſlackneſs of the current at the point, it is neceſſary to obſerve, that the ſtrongeſt part of it, inſtead of turning ſhort round the point, preſerves for ſome time the direction given it by the laſt ſteep bank, and is accordingly thrown obliquely acroſs the bed of the river to the bay on the oppoſite ſide, and purſues its courſe along it, till the intervention of another point again obliges it to change ſides.

In thoſe few parts of the river that are ſtraight, the banks undergo the leaſt alteration †, as the current runs parallel to

* In the dry ſeaſon ſome of theſe banks are more than 30 feet high, and often fall down in pieces of many tons weight, and occaſion ſo ſudden and violent an agitation of the water, as ſometimes to ſink large boats that happen to be near the ſhore.

† It is more than probable, that the ſtraight parts owe their exiſtence to the tenacity of the ſoil of which their banks are compoſed. Whatever the cauſe may be, the effect very clearly points out ſuch ſituations as the propereſt for placing towns in.

them ;

them; but the leaſt inflection of courſe has the effect of throwing the current againſt the bank; and if this happens in a part where the ſoil is compoſed of looſe ſand, it produces in time a ſerpentine winding.

It is evident, that the repeated additions made to the ſhelving bank before mentioned, become in time an encroachment on the channel of the river; and this is again counter-balanced by the depredations made on the oppoſite ſteep bank, the fragments of which, either bring about a repetition of the circumſtances above recited, or form a bank or ſhallow in the midſt of the channel. Thus a ſteep and a ſhelving bank are alternately formed in the crooked parts of the river (the ſteep one being the *indented* ſide, and the ſhelving one the *projecting*); and thus, a continual fluctuation of courſe is induced in all the winding parts of the river; each meander having a perpetual tendency to deviate more and more from the line of the general courſe of the river, by eating deeper into the bays, and at the ſame time adding to the points, till either the oppoſite bays meet, or the ſtream breaks through the narrow iſthmus, and reſtores a temporary ſtraightneſs to the channel.

Several of the windings of the Ganges and its branches are faſt approaching to this ſtate; and in others, it actually exiſts at preſent. The experience of theſe changes ſhould operate againſt attempting canals of any length, in the higher parts of the country; and I much doubt, if any in the lower parts would long continue navigable. During eleven years of my reſidence in Bengal, the outlet or head of the Jellinghy River was gradually removed three quarters of a mile farther down: and by two ſurveys of a part of the adjacent bank of the Ganges, taken about the diſtance of nine years from each other, it appeared that the breadth of an Engliſh mile and a half had been

taken

taken away. This is, however, the moſt rapid change that I have noticed; a mile in ten or twelve years being the uſual rate of incroachment, in places where the current ſtrikes with the greateſt force, namely, where two adjoining reaches approach neareſt to a right angle. In ſuch ſituations it not unfrequently excavates gulfs * of conſiderable length within the bank. Theſe gulfs are in the direction of the ſtrongeſt parts of the ſtream; and are, in fact, the *young ſhoots* (if I may ſo expreſs myſelf) which in time ſtrike out and become branches of the river; for we generally find them at thoſe turnings that have the ſmalleſt angles †.

Two cauſes, widely different from each other, occaſion the meandering courſes of rivers; the one, the irregularity of the ground through which they run, which obliges them to wander in queſt of a declivity; the other, the looſeneſs of the ſoil, which yields to the friction of the border of the ſtream. The meanders in the firſt caſe, are, of courſe, as digreſſive and irregular as the ſurface they are projected on: but, in the latter, they are ſo far reducible to rule, that rivers of unequal bulk will, under ſimilar circumſtances, take a circuit to wind in, whoſe extent is in proportion to their reſpective breadths: for I have obſerved, that

* The Count DE BUFFON adviſes the digging of ſuch gulfs in the banks of ordinary rivers, with a view to divert the current, when bridges or other buildings are endangered by it.

† The courſes of theſe branches at the efflux, generally, if not always, become retrograde to the courſe of the river: for, a ſand bank accumulating at the upper point of ſeparation, gives an oblique direction upwards, to the ſtream, which would otherwiſe run out at right angles. This ſand bank being always on the increaſe, occaſions a corroſion of the oppoſite bank; and by this means all, or moſt of the outlets have a progreſſive motion downwards; as I have before remarked of the Jellinghy River, in the foregoing page.

when a branch of the Ganges is fallen ſo low as to occupy only a part of its bed, it no longer continues in the line of its old courſe; but works itſelf a new channel, which winds from ſide to ſide acroſs the former one. I have obſerved too, that in two ſtreams, of equal ſize, that which has the ſloweſt current has alſo the ſmalleſt windings: for as theſe (in the preſent caſe) are ſolely owing to the depredations made on the banks by the force of the current; ſo the extent of theſe depredations, or, in other words, the dimenſions of the windings, will be determined by the degree of force acting on the banks.

The windings of the Ganges in the plains, are, doubtleſs, owing to the looſeneſs of the ſoil: and (I think) the proof of it is, that they are perpetually changing; which thoſe, originally induced by an inequality of ſurface, can ſeldom, or never do *.

I can eaſily ſuppoſe, that if the Ganges was turned into a ſtraight canal, cut through the ground it now traverſes in the moſt winding parts of its courſe, its ſtraightneſs would be of ſhort duration. Some yielding part of the bank, or that which happened to be the moſt ſtrongly acted on, would firſt be corroded or diſſolved: thus a bay or cavity would be formed in the ſide of the bank. This begets an inflection of the current, which, falling obliquely on the ſide of the bay, corrodes it inceſſantly. When the current has paſſed the innermoſt part of the bay, it receives a new direction, and is thrown

* It has been remarked, that the courſes of rivers become more winding as they approach the ſea. This, I believe, will only hold good in ſuch as take the latter part of their courſe through a ſandy ſoil. In the Ganges, and other rivers ſubject to conſiderable variations in the bulk of their ſtreams, the beſt marks of the vicinity of the ſea are, the lowneſs of the river banks, and the increaſing muddineſs of the ſhallows in its bed.

obliquely

obliquely towards the oppoſite ſide of the canal, depoſiting in its way the matter excavated from the bay, and which begins to form a ſhallow or bank contiguous to the border of the canal. Here then is the origin of ſuch windings as owe their exiſtence to the nature of the ſoil. The bay, ſo corroded, in time becomes large enough to give a new direction to the body of the canal: and the matter excavated from the bay is ſo diſpoſed as to aſſiſt in throwing the current againſt the oppoſite bank, where a proceſs, ſimilar to that I have been deſcribing, will be begun.

The action of the current on the bank will alſo have the effect of deepening the border of the channel near it; and this again increaſes the velocity of the current in that part. Thus would the canal gradually take a new form, till it became what the river now is. Even when the windings have leſſened the deſcent one half, we ſtill find the current too powerful for the banks to withſtand it.

There are not wanting inſtances of a total change of courſe in ſome of the Bengal rivers *. The Coſa River (equal to the Rhine) once ran by Purneah, and joined the Ganges oppoſite Rajemal. Its junction is now 45 miles higher up. Gour, the ancient capital of Bengal, ſtood on the banks of the Ganges.

Appearances favour very ſtrongly the opinion, that the Ganges had its former bed in the tract now occupied by the lakes and moraſſes between Nattore and Jaffiergunge, ſtriking out of its preſent courſe at Bauleah, and paſſing by Pootyah. With an equal degree of probability (favoured by tradition) we may trace its ſuppoſed courſe by Dacca, to a junction with the Burrampooter or Megna near Fringybazar; where the accumu-

* The Mootyjyl lake is one of the windings of a former channel of the Coſſimbuzar River.

lation of two ſuch mighty ſtreams probably ſcooped out the preſent amazing bed of the Megna *.

In tracing the ſea coaſt of the Delta, we find no leſs than eight openings; each of which, without heſitation, one pronounces to have been in its time the principal mouth of the Ganges. Nor is the occaſional deviation of the principal branch, probably, the only cauſe of fluctuation in the dimenſions of the Delta. One obſerves, that the Deltas of capital rivers (the tropical ones particularly) encroach upon the ſea. Now, is not this owing to the mud and ſand brought down by the rivers, and gradually depoſited, from the remoteſt ages down to the preſent time? The rivers, we know, are loaded with mud and ſand at their entrance into the ſea; and we alſo know, that the ſea recovers its tranſparency at the diſtance of twenty leagues from the coaſt; which can only ariſe from the waters having precipitated their earthy particles within that ſpace. The ſand and mud banks at this time, extend twenty miles off ſome of the iſlands in the mouths of the Ganges and Burrampooter; and in many places riſe within a few feet of the ſurface. Some future generation will probably ſee theſe banks riſe above water, and ſucceeding ones poſſeſs and cultivate them! Next to earthquakes, perhaps the floods of the tropical rivers produce the quickeſt alterations in the face of our globe. Extenſive iſlands are formed in the channel of the Ganges, during a period far ſhort of that of a man's life; ſo that the whole proceſs lies

* Megna and Burrampooter are names belonging to the ſame river in different parts of its courſe. The Megna falls into the Burrampooter; and, though a much ſmaller river, communicates its name to the other during the reſt of its courſe.

within

within the compaſs of his obſervation *. Some of theſe iſlands, four or five miles in extent, are formed at the angular turnings of the river, and were originally large ſand banks thrown up round the points (in the manner before deſcribed) but afterwards inſulated by breaches of the river. Others are formed in the ſtraight parts of the river, and in the middle of the ſtream; and owe their origin to ſome obſtruction lurking at the bottom. Whether this be the fragments of the river bank; a large tree ſwept down from it; or a ſunken boat; it is ſufficient for a foundation: and a heap of ſand is quickly collected below it. This accumulates amazingly faſt: in the courſe of a few years it peeps above water, and having now uſurped a conſiderable portion of the channel, the river borrows on each ſide to ſupply the deficiency in its bed; and in ſuch parts of the river we always find ſteep banks on both ſides †. Each periodical flood brings an addition of matter to this growing iſland; increaſing it in height as well as extenſion, until its top is perfectly on a level with the banks that include it: and at that period of its growth it has mould enough on it for the purpoſes of cultivation, which is owing to the mud left on it when the waters ſubſide, and is indeed a part of the œconomy which nature obſerves in fertilizing the lands in general.

Whilſt the river is forming new iſlands in one part, it is ſweeping away old ones in other parts. In the progreſs of this deſtructive operation, we have opportunities of obſerving, by means of the ſections of the falling bank, the regular diſtri-

* Accordingly, the laws reſpecting alluvion are aſcertained with great preciſion.

† This evidently points out the means for preventing encroachments on a river bank in the ſtraight parts of its courſe, *viz.* to remove the ſhallows in the middle of its channel.

bution

bution of the ſeveral ſtrata of ſand and earths, lying above one another in the order in which they decreaſe in gravity. As they can only owe this diſpoſition to the agency of the ſtream that depoſited them, it would appear, that theſe ſubſtances are ſuſpended at different heights in the ſtream, according to their reſpective gravities. We never find a ſtratum of earth under one of ſand; for the muddy particles float neareſt the ſurface *. I have counted ſeven diſtinct ſtrata in a ſection of one of theſe iſlands. Indeed, not only the iſlands, but moſt of the river banks wear the ſame appearance: for as the river is always changing its preſent bed, and verging towards the ſite of ſome former one now obliterated, this muſt neceſſarily be the caſe.

As a ſtrong preſumptive proof of the wandering of the Ganges from the one ſide of the Delta to the other, I muſt obſerve, that there is no appearance of *virgin* earth between the Tiperah Hills on the eaſt, and the province of Burdwan on the weſt; nor on the north till we arrive at Dacca and Bauleah. In all the ſections of the numerous creeks and rivers in the Delta, nothing appears but ſand and black mould in regular ſtrata, till we arrive at the clay that forms the lower part of their beds. There is not any ſubſtance ſo coarſe as gravel either in the Delta or nearer the ſea than 400 miles †, where a rocky point, a part of the baſe of the neighbouring hills, projects into the river: but out of the vicinity of the great rivers the ſoil is either red, yellow, or of a deep brown.

* A glaſs of water taken out of the Ganges, when at its height, yields about one part in four of mud. No wonder then that the ſubſiding waters ſhould quickly form a ſtratum of earth; or that the Delta ſhould encroach upon the ſea!

† At Oudanulla.

I come

I come now to the particulars of the annual ſwelling and overflowing of the Ganges *.

It appears to owe its increaſe as much to the rain water that falls in the mountains contiguous to its ſource, and to the ſources of the great northern rivers that fall into it, as to that which falls in the plains of Hindooſtan; for it riſes fifteen feet and a half out of thirty-two (the ſum total of its riſing) by the latter end of June: and it is well known, that the rainy ſeaſon does not begin in moſt of the flat countries till about that time. In the mountains it begins early in † April; and by the latter end of that month, when the rain-water has reached Bengal, the rivers begin to riſe, but by very ſlow degrees; for the increaſe is only about an inch *per* day for the firſt fortnight. It then gradually augments to two and three inches before any

* An opinion has long prevailed, that the ſwelling of the Ganges, previous to the commencement of the rainy ſeaſon in the flat countries, is in a great meaſure owing to the melting of the ſnow in the mountains. I will not go ſo far as totally to diſallow the fact; but can by no means ſuppoſe, that the quantity of ſnow water bears any proportion to the increaſe of the river.

† The vaſt collection of vapours, wafted from the ſea by the ſoutherly or ſouth-weſt monſoon, are ſuddenly ſtopped by the lofty ridge of mountains that runs from eaſt to weſt through Thibet. It is obvious, that the accumulation and condenſation of theſe vapours, muſt firſt happen in the neighbourhood of the obſtacle; and ſucceſſively in places more remote, as freſh ſupplies arrive to fill the atmoſphere. Hence the priority of commencement of the rainy ſeaſon in places that lie neareſt the mountains.

All the rivers that are ſituated within the limits of the monſoons, or ſhifting trade winds, are ſubject to overflowings at annually ſtated periods, like the Ganges: and theſe periods return during the ſeaſon of the ſoutherly wind, that being the only wind which brings vapours from the ſea; and this being periodical, the falls of rain muſt neceſſarily be ſo too.

The northerly wind, which blows only over the land, is dry; for no rain (except caſual ſhowers) falls during the continuance of that monſoon.

quantity

quantity of rain falls in the flat countries; and when the rain becomes general, the increaſe on a medium is five inches *per* day. By the latter end of July all the lower parts of Bengal, contiguous to the Ganges and Burrampooter, are overflowed, and form an inundation of more than a hundred miles in width; nothing appearing but villages and trees, excepting very rarely the top of an elevated ſpot (the artificial mound of ſome deſerted village) appearing like an iſland.

The inundations in Bengal differ from thoſe in Egypt in this particular, that the Nile owes its floods *entirely* to the rain-water that falls in the mountains near its ſource; but the inundations in Bengal are as much occaſioned by the rain that falls there, as by the waters of the Ganges; and as a proof of it, the lands in general are overflowed to a conſiderable height long before the bed of the river is filled. It muſt be remarked, that the ground adjacent to the river bank, to the extent of ſome miles, is conſiderably higher than the reſt of the country*, and ſerves to ſeparate the waters of the inundation from thoſe of the river until it overflows. This high ground is in ſome ſeaſons covered a foot or more; but the height of the inundation within, varies, of courſe, according to the irregularities of the ground, and is in ſome places twelve feet.

Even when the inundation becomes general, the river ſtill ſhews itſelf, as well by the graſs and reeds on its banks, as by its rapid and muddy ſtream; for the water of the inundation acquires a blackiſh hue, by having been ſo long ſtagnant

* This property of the bank is well accounted for by Count BUFFON, who imputes it to the precipitation of mud made by the waters of the river, when it overflows. The inundation, ſays he, purifies itſelf as it flows over the plain; ſo that the precipitation muſt be greateſt on the parts neareſt to the margin of the river.

amongſt graſs and other vegetables: nor does it ever loſe this tinge, which is a proof of the predominancy of the rain water over that of the river; as the ſlow rate of motion of the inundation (which does not exceed half a mile *per* hour) is of the remarkable flatneſs of the country.

There are particular tracts of land, which, from the nature of their culture, and ſpecies of productions, require leſs moiſture than others; and yet, by the lowneſs of their ſituation, would remain too long inundated, were they not guarded by dikes or dams, from ſo copious an inundation as would otherwiſe happen from the great elevation of the ſurface of the river above them. Theſe dikes are kept up at an enormous expence; and yet do not always ſucceed, for want of tenacity in the ſoil of which they are compoſed.

During the ſwoln ſtate of the river, the tide totally loſes its effect of counteracting the ſtream; and in a great meaſure that of ebbing and flowing, except very near the ſea. It is not uncommon for a ſtrong wind, that blows up the river for any continuance, to ſwell the waters two feet above the ordinary level at that ſeaſon: and ſuch accidents have occaſioned the loſs of whole crops of rice*. A very tragical event happened at Luckipour † in 1763, by a ſtrong gale of wind conſpiring with a high ſpring tide, at a ſeaſon when the periodical flood was within a foot and half of its higheſt pitch. It is ſaid that the waters roſe ſix feet above the ordinary level. Certain it is, that

* The rice I ſpeak of is of a particular kind; for the growth of its ſtalk keeps pace with the increaſe of the flood at ordinary times, but is deſtroyed by a too ſudden riſe of the water. The harveſt is often reaped in boats. There is alſo a kind of graſs which overtops the flood in the ſame manner, and at a ſmall diſtance has the appearance of a field of the richeſt verdure.

† This place is ſituated about fifty miles from the ſea.

the inhabitants of a conſiderable diſtrict, with their houſes and cattle, were totally ſwept away; and, to aggravate their diſtreſs, it happened in a part of the country which ſcarce produces a ſingle tree for a drowning man to eſcape to.

Embarkations of every kind traverſe the inundation: thoſe bound upwards, availing themſelves of a direct courſe and ſtill water, at a ſeaſon when every ſtream ruſhes like a torrent. The wind too, which at this ſeaſon blows regularly from the ſouth-eaſt *, favours their progreſs; inſomuch, that a voyage, which takes up nine or ten days by the courſe of the river when confined within its banks, is now effected in ſix. Huſbandry and grazing are both ſuſpended; and the peaſant traverſes in his boat, thoſe fields which in another ſeaſon he was wont to plow; happy that the elevated ſite of the river banks place the herbage they contain, within his reach, otherwiſe his cattle muſt periſh.

The following is a table of the gradual increaſe of the Ganges and its branches, according to obſervations made at Jellinghy and Dacca.

At Jellinghy.	Ft.	In.	At Dacca. Ft.	In.
In May it roſe -	6	0	2	4
June - - -	9	6	4	6
July - - -	12	6	5	6
In the firſt half of Auguſt	4	0	1	11
	32	0	14	3

* Although in the gulf or bay of Bengal the monſoon blows from the S.S.W. and S.W. yet in the eaſtern and northern parts of Bengal it blows from the S.E. or E.S.E.

Theſe obſervations were made in a ſeaſon, when the waters roſe rather higher than uſual; ſo that we may take 31 feet for the medium of the increaſe.

The inundation is nearly at a ſtand for ſome days preceding the middle of Auguſt, when it begins to run off; for although great quantities of rain fall in the flat countries, during Auguſt and September, yet, by a partial ceſſation of the rains in the mountains, there happens a deficiency in the ſupplies neceſſary to keep up the inundation *. The quantity of the daily decreaſe of the river is nearly in the following proportion: during the latter half of Auguſt, and all September, from three to four inches; from September to the end of November, it gradually leſſens from three inches to an inch and a half; and from November to the latter end of April, it is only half an inch *per* day at a medium. Theſe proportions muſt be underſtood to relate to ſuch parts of the river as are removed from the influence of the tides; of which more will be ſaid by and by. The decreaſe of the inundation does not always keep pace with that of the river, by reaſon of the height of the banks; but after the beginning of October, when the rain has nearly ceaſed, the remainder of the inundation goes off quickly by evaporation, leaving the lands highly manured, and in a ſtate fit to receive the ſeed, after the ſimple operation of plowing.

There is a circumſtance attending the increaſe of the Ganges, and which, I believe, is little known or attended to; becauſe few people have made experiments on the heights to which the

* I have ſtated the middle of Auguſt for the period when the waters begin to run off; and in general it happens with more regularity than the viciſſitudes of the ſeaſons do. But there are exceptions to it; for in the year 1774 the rivers kept up for near a month after the uſual time.

periodical flood riſes in different places. The circumſtance I allude to, is, the difference of the quantity of the increaſe (as expreſſed in the foregoing table) in places more or leſs remote from the ſea. It is a fact, confirmed by repeated experiments, that from about the place where the tide commences, to the ſea, the height of the periodical increaſe diminiſhes gradually, until it totally diſappears at the point of confluence. Indeed, this is perfectly conformable to the known laws of fluids: the Ocean preſerves the ſame level at all ſeaſons (under ſimilar circumſtances of tide) and neceſſarily influences the level of all the waters that communicate with it, unleſs precipitated in the form of a cataract. Could we ſuppoſe, for a moment, that the increaſed column of water, of 31 feet perpendicular, was continued all the way to the ſea, by ſome preternatural agency: whenever that agency was removed, the head of the column would diffuſe itſelf over the Ocean, and the remaining parts would follow, from as far back as the influence of the Ocean extended; forming a ſlope, whoſe perpendicular height would be 31 feet. This is the preciſe ſtate in which we find it. At the point of junction with the ſea, the height is the ſame in both ſeaſons at equal times of the tide. At Luckipour there is a difference of about ſix feet between the heights in the different ſeaſons; at Dacca, and places adjacent, 14; and near Cuſtee, 31 feet. Here then is a regular ſlope; for the diſtances between the places bear a proportion to the reſpective heights. This ſlope muſt add to the rapidity of the ſtream; for, ſuppoſing the deſcent to have been originally four inches *per* mile, this will increaſe it to about five and an half. Cuſtee is about 240 miles from the ſea, by the courſe of the river; and the ſurface of the river there, during the dry ſeaſon, is about 80

feet

feet above the level of the ſea at high water *. Thus far does the Ocean manifeſt its dominion in both ſeaſons: in the one by the ebbing and flowing of its tides; and in the other by depreſſing the periodical flood, till the ſurface of it coincides as nearly with its own, as the deſcent of the channel of the river will admit †.

Similar circumſtances take place in the Jellinghy, Hoogly, and Burrampooter Rivers; and, I ſuppoſe, in all others that are ſubject either to periodical or occaſional ſwellings.

Not only does the flood diminiſh near the ſea, but the river banks diminiſh in the ſame proportion; ſo that in the dry ſeaſon the height of the periodical flood may be known by that of the bank.

I am aware of an objection that may be made to the above ſolution; which is, that the lowneſs of the banks in places near the ſea, is the true reaſon why the floods do not attain ſo conſiderable a height, as in places farther removed from it, and where the banks are high; for that the river, wanting a bank to confine it, diffuſes itſelf over the ſurface of the country. In

* The tides in the River Amazons are perceptible at 600 miles above its mouth; but at an elevation of only 90 feet, according to M. DE CONDAMINE. It remains to be told what the ſtate of the river was at the time of making the experiment; becauſe the land-floods have the effect of ſhortening the limits of the tide's way.

† The Count DE BUFFON has ſlightly mentioned this circumſtance attending the ſwelling of rivers; but imputes it to the increaſed velocity of the current, as the river approaches the ſea: which, ſays he, carries off the inundation ſo quick, as to abate its height. Now (with the utmoſt deference to ſo great an authority) I could never perceive, that the current, either in the Ganges, or any other river, was ſtronger near the ſea than at a diſtance from it. Even if we admit an acceleration of the current during the ebb tide, the flux retards it in ſo conſiderable a degree, as at leaſt to counter-balance the effects produced by the temporary increaſe of velocity.

anſwer

anſwer to this, I ſhall obſerve, that it is proved by experiment, that at any given time, the quantity of the increaſe in different places, bears a juſt proportion to the ſum total of the increaſe in each place reſpectively: or, in other words, that when the river has riſen three feet at Dacca, where the whole riſing is about 14 feet; it will have roſe upwards of ſix feet and a half at Cuſtee, where it riſes 31 feet in all.

The quantity of water diſcharged by the Ganges, in one ſecond of time, during the dry ſeaſon, is 80,000 cubic feet; but in the place where the experiment was made, the river, when full, has thrice the volume of water in it; and its motion is alſo accelerated in the proportion of 5 to 3: ſo that the quantity diſcharged in a ſecond at that ſeaſon is 405,000 cubic feet. If we take the medium the whole year through, it will be nearly 180,000 cubic feet in a ſecond.

THE Burrampooter, which has its ſource from the oppoſite ſide of the ſame mountains that give riſe to the Ganges, firſt takes its courſe eaſtward (or directly oppoſite to that of the Ganges) through the country of Thibet, where it is named Sanpoo or Zanciu, which bears the ſame interpretation as the Gonga of Hindooſtan: namely, the River. The courſe of it through Thibet, as given by Father DU HALDE, and formed into a map by Mr. D'ANVILLE, though ſufficiently exact for the purpoſes of general geography, is not particular enough to aſcertain the preciſe length of its courſe. After winding with a rapid current through Thibet, it waſhes the border of the territory of Laſſa (in which is the reſidence of the grand Lama) and then deviating from an eaſt to a ſouth-eaſt courſe, it approaches within 220 miles of Yunan, the weſternmoſt province of

of China. Here it appears, as if undetermined whether to attempt a paſſage to the ſea by the Gulf of Siam, or by that of Bengal; but ſeemingly determining on the latter, it turns ſuddenly to the weſt through Aſſam, and enters Bengal on the north-eaſt. I have not been able to learn the exact place where it changes its name; but as the people of Aſſam call it Burrampoot, it would appear, that it takes this name on its entering Aſſam. After its entry into Bengal, it makes a circuit round the weſtern point of the Garrow Mountains; and then, altering its courſe to ſouth, it meets the Ganges about 40 miles from the ſea.

Father DU HALDE expreſſes his doubts concerning the courſe that the Sanpoo takes after leaving Thibet, and only ſuppoſes generally that it falls into the gulf of Bengal. M. D'ANVILLE, his geographer, with great reaſon ſuppoſed the Sanpoo and Ava River to be the ſame: and in this he was juſtified by the information which his materials afforded him: for the Burrampooter was repreſented to him, as one of the inferior ſtreams that contributed its waters the Ganges, and not as its equal or ſuperior; and this was ſufficient to direct his reſearches, after the mouth of the Sanpoo River, to ſome other quarter. The Ava River, as well from its bulk, as the bent of its courſe for ſome hundred miles above its mouth, appeared to him to be a continuation of the river in queſtion: and it was accordingly deſcribed as ſuch in his maps, the authority of which was juſtly eſteemed as deciſive; and, till the year 1765, the Burrampooter, as a capital river, was unknown in Europe.

On tracing this river in 1765, I was no leſs ſurprized, at finding it rather larger than the Ganges, than at its courſe previous to its entering Bengal. This I found to be from the eaſt; although all the former accounts repreſented it as from the north:

north: and this unexpected diſcovery ſoon led to enquiries, which furniſhed me with an account of its general courſe to within 100 miles of the place where DU HALDE left the Sanpoo. I could no longer doubt, that the Burrampooter and Sanpoo were one and the ſame river: and to this was added the poſitive aſſurances of the Aſſamers, "That *their* river came "from the north-weſt, through the Bootan mountains." And to place it beyond a doubt, that the Sanpoo River is not the ſame with the river of Ava, but that this laſt is the great Nou Kian of Yunan; I have in my poſſeſſion a manuſcript draught of the Ava River, to within 150 miles of the place where DU HALDE leaves the Nou Kian, in its courſe towards Ava; together with very authentic information that this river (named Irabattey by the people of Ava) is navigable from the city of Ava into the province of Yunan in China *.

The Burrampooter, during a courſe of 400 miles through Bengal, bears ſo intimate a reſemblance to the Ganges, except in one particular, that one deſcription may ſerve for both. The exception I mean is, that, during the laſt 60 miles before its junction with the Ganges, it forms a ſtream which is regularly from four to five miles wide, and but for its freſhneſs might paſs for an arm of the ſea. Common deſcription fails in an attempt to convey an adequate idea of the grandeur of this magnificent object; for,

——— Scarce the muſe
Dares ſtretch her wing o'er this enormous maſs
Of ruſhing water; to whoſe dread expanſe,
Continuous depth, and wond'rous length of courſe,

* The courſes of the Burrampooter and Ganges, as well as that of the Ava River from Yunan to the ſea, will ſhortly be deſcribed in a large ſheet map of Hindooſtan.

Our

Our floods are rills ———
Thus pouring on, it proudly ſeeks the deep,
Whoſe vanquiſh'd tide, recoiling from the ſhock,
Yields to this liquid weight ———

THOMSON'S Seaſons.

I have already endeavoured to account for the ſingular breadth of the Megna, by ſuppoſing that the Ganges once joined it where the Iſſamutty now does; and that their joint waters ſcooped out its preſent bed. The preſent junction of theſe two mighty rivers below Luckipour, produces a body of running freſh water, hardly to be equalled in the old hemiſphere, and, perhaps, not exceeded in the new. It now forms a gulf interſperſed with iſlands, ſome of which rival, in ſize and fertility, our Iſle of Wight. The water at ordinary times is hardly brackiſh at the extremities of theſe iſlands; and, in the rainy ſeaſon, the ſea (or at leaſt the ſurface of it) is perfectly freſh to the diſtance of many leagues out.

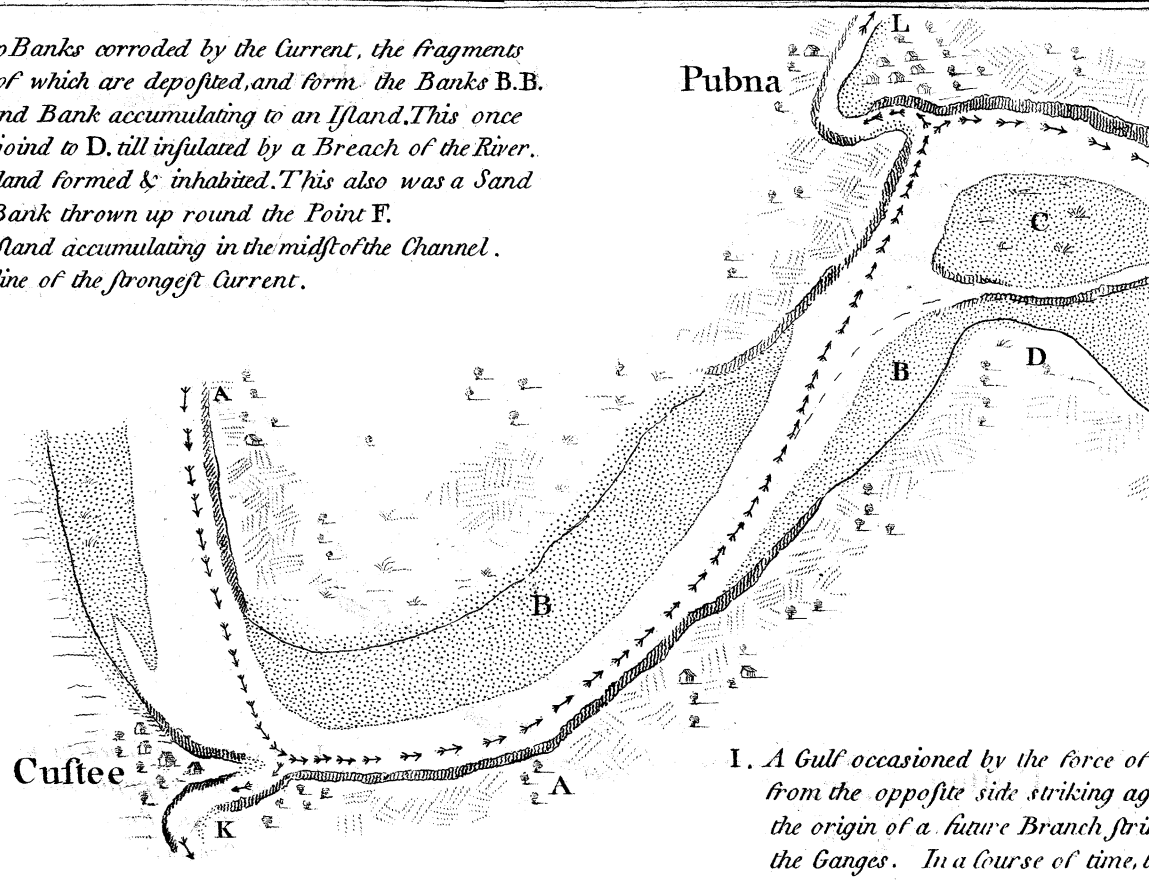
The *Bore* (which is known to be a ſudden and abrupt influx of the tide into a river or narrow ſtrait) prevails in the principal branches of the Ganges, and in the Megna; but the Hoogly River, and the paſſages between the iſlands and ſands ſituated in the gulf, formed by the confluence of the Ganges and Megna, are more ſubject to it than the other rivers. This may be owing partly, to their having greater embouchures in proportion to their channels, than the others have, by which means a larger proportion of tide is forced through a paſſage comparatively ſmaller; and partly, to there being no capital openings near them, to draw off any conſiderable portion of the accumulating tide. In the Hoogly or Calcutta River, the *Bore* commences at Hoogly Point (the place where the river firſt contracts itſelf)

and is perceptible above Hoogly Town; and ſo quick is its motion, that it hardly employs four hours in travelling from one to the other, although the diſtance is near 70 miles. At Calcutta, it ſometimes occaſions an inſtantaneous riſe of five feet: and both here, and in every other part of its track, the boats, on its approach, immediately quit the ſhore, and make for ſafety to the middle of the river.

In the channels, between the iſlands in the mouth of the Megna, &c. the height of the *Bore* is ſaid to exceed twelve feet; and is ſo terrific in its appearance, and dangerous in its conſequences, that no boat will venture to paſs at ſpring tide. After the tide is fairly paſt the iſlands, no veſtige of a *Bore* is ſeen, which may be owing to the great width of the Megna, in compariſon with the paſſages between the iſlands; but the effects of it are viſible, enough by the ſudden riſing of the tides.

PLAN of part of the Course of the GANGES, *to explain*

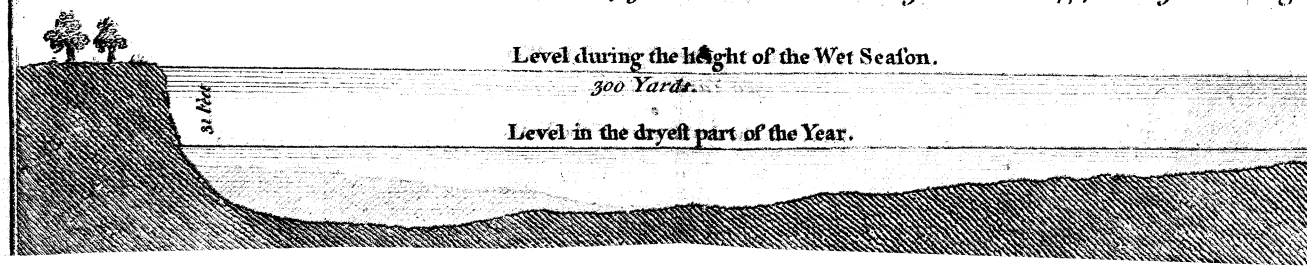
A.A. *Steep Banks corroded by the Current, the fragments of which are depoſited, and form the Banks* B.B.
C. *A Sand Bank accumulating to an Iſland. This once joind to* D. *till inſulated by a Breach of the River.*
E. *An Island formed & inhabited. This also was a Sand Bank thrown up round the Point* F.
G. *An Iſland accumulating in the midſt of the Channel.*
H. *The line of the ſtrongeſt Current.*



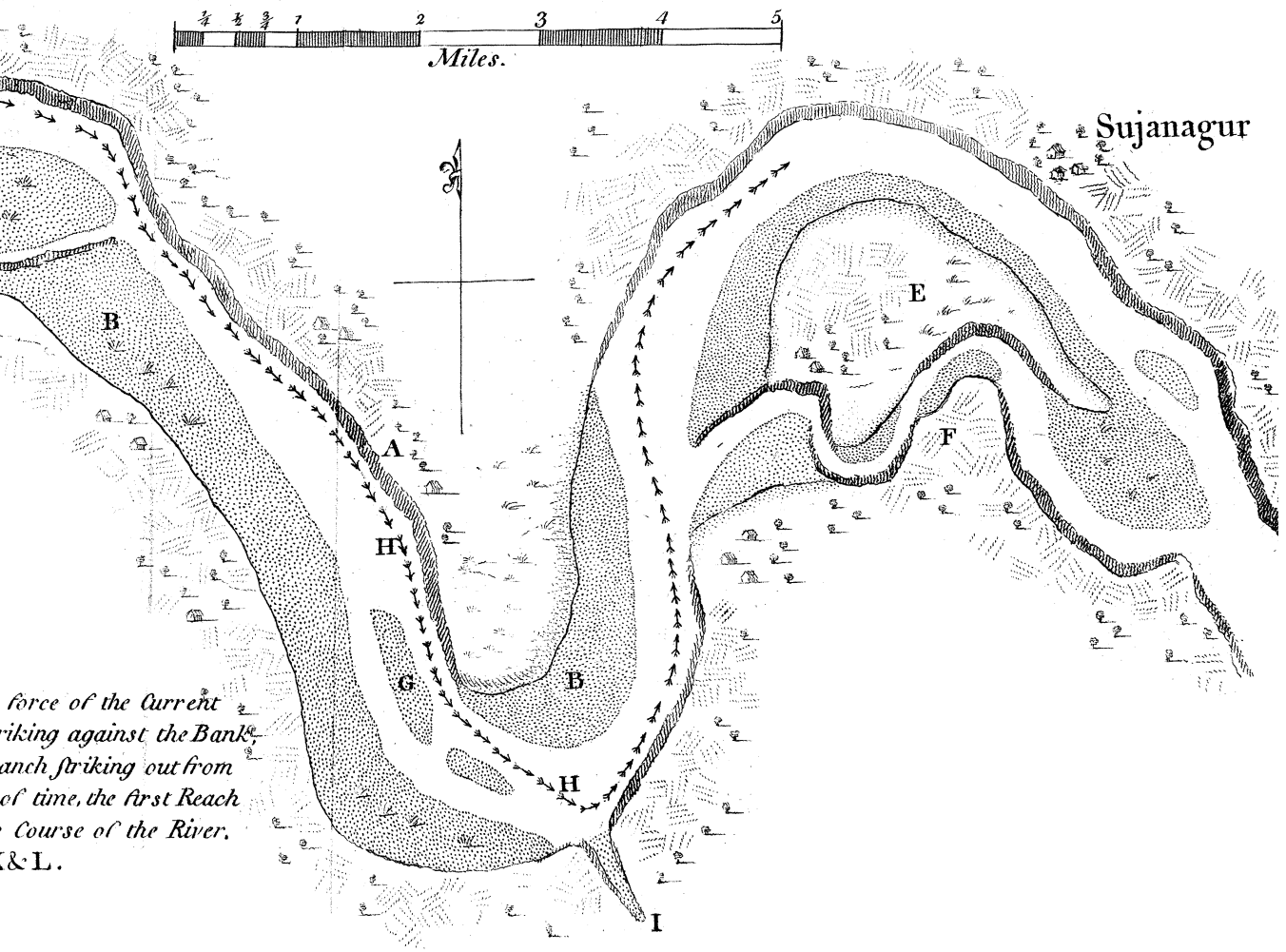
I. *A Gulf occaſioned by the force of from the oppoſite ſide ſtriking ag the origin of a future Branch ſtri the Ganges. In a Courſe of time, t becomes Retrograde to the Courſe* *(See Note page 97)* *as at* K & L.

SECTION of a Branch of the GANGES, *as a furth*

N.B. This is exactly ſimilar to the Section of the winding parts of the Ganges



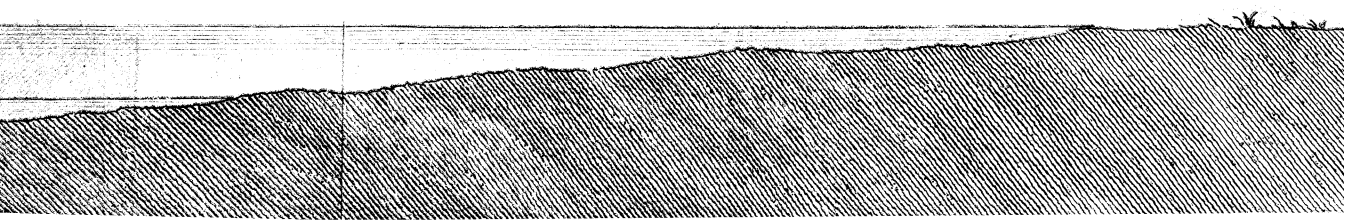
xplain the nature of the steep and shelving Banks, &c.



force of the Current
riking against the Bank.
anch striking out from
of time, the first Reach
Course of the River.
X & L.

a further explanation of the steep and shelving Banks.

e Ganges itself, except in the article of width.



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PLAN of part of the Course of the GANGES, *to explain the nature of the steep and shelving Banks, &c.*

Philos. Trans. Vol. LXXI. Tab. IV. p. 114.

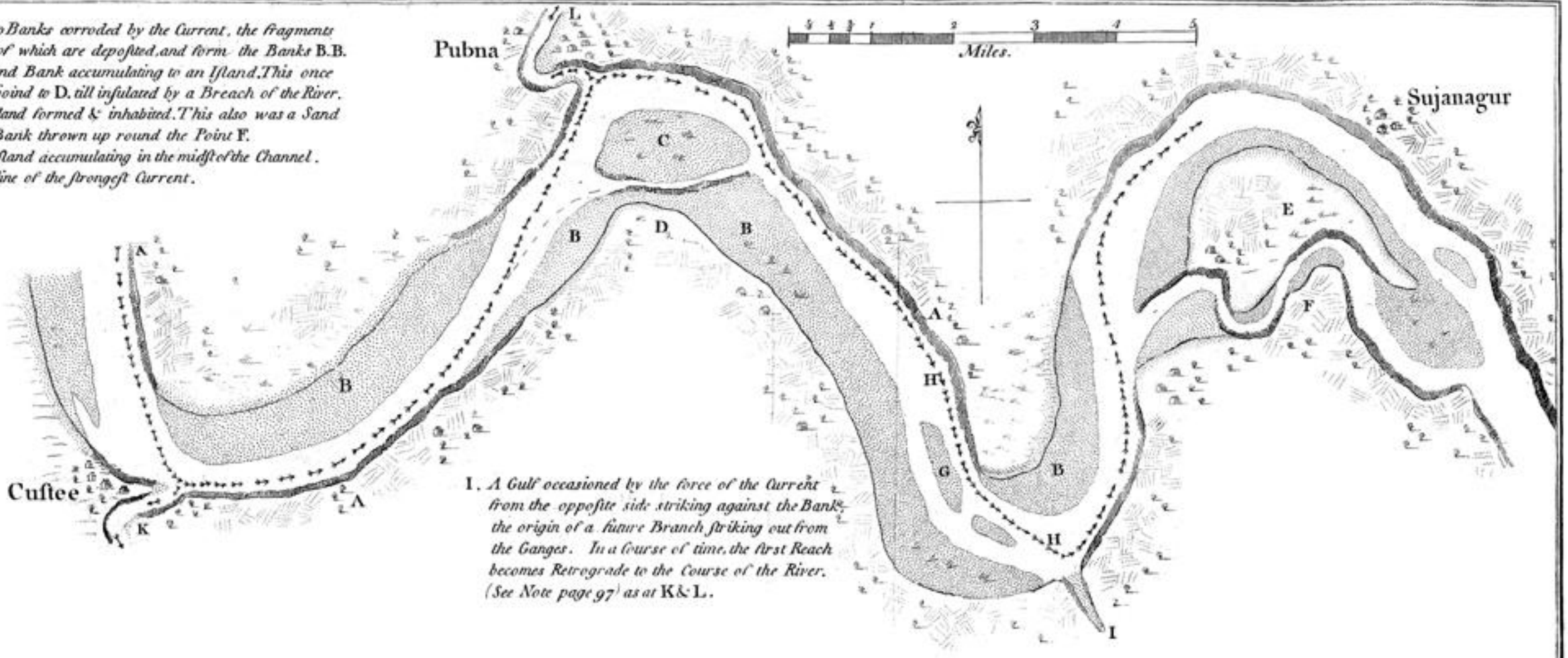
A.A. *Steep Banks corroded by the Current, the fragments of which are deposited, and form the Banks* B.B.

C. *A Sand Bank accumulating to an Island. This once joind to* D. *till insulated by a Breach of the River.*

E. *An Island formed & inhabited. This also was a Sand Bank thrown up round the Point* F.

G. *An Island accumulating in the midst of the Channel.*

H. *The line of the strongest Current.*



I. *A Gulf occasioned by the force of the Current from the opposite side striking against the Bank, the origin of a future Branch striking out from the Ganges. In a Course of time, the first Reach becomes Retrograde to the Course of the River. (See Note page 97) as at* K & L.

SECTION of a Branch of the GANGES, *as a further explanation of the steep and shelving Banks.*

N.B. This is exactly similar to the Section of the winding parts of the Ganges itself, except in the article of width.